L Number	Hits	Search Text	DB	Time stamp
13	213	((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 ((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)))	EPO; JPO; DERWENT	2002/05/19 20:09
14	55	(((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 ((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)))) AND (access$4 OR obtain$6 OR unlock$4)	EPO; JPO; DERWENT	2002/05/19 20:09
15	1	((((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 ((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)))) AND (access$4 OR obtain$6 OR unlock$4)) AND (((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)) WITH ((grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1) AND (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6)))	EPO; JPO; DERWENT	2002/05/19 20:16
16	532651	(encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))	EPO; JPO; DERWENT	2002/05/19 20:17
17	3944	((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))	EPO; JPO; DERWENT	2002/05/19 20:18
18	352	(((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))	EPO; JPO; DERWENT	2002/05/19 20:18
19	7	((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6) WITH (sequen$5 OR pattern$4 OR position$4 OR spatial$2 OR spac$3 OR locat$4) WITH (graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5))	EPO; JPO; DERWENT	2002/05/19 20:19

20	2	(((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6) WITH (sequen$5 OR pattern$4 OR position$4 OR spatial$2 OR spac$3 OR locat$4) WITH (graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5))) NOT us.pc.	EPO; JPO; DERWENT	2002/05/19 20:20

DERWENT-ACC-NO: 1993-077869
DERWENT-WEEK: 199614

TITLE: Automatically recognising objects esp. irregular ones e.g. cell
clusters - supplying window comparator with upper and lower threshold valves
with image point signals from video camera

INVENTOR: HOEFER, H; KAMUTZKI, H

PATENT-ASSIGNEE: HOEFER H[HOEFI], KAMUTZKI H[KAMUI]

PRIORITY-DATA: 1991DE-4141880 (December 18, 1991)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
DE 4141880 C1	March 11, 1993	N/A	028	G06K 009/68
ES 2081204 T3	February 16, 1996	N/A	000	G06T 007/60
WO 9312503 A1	June 24, 1993	N/A	046	G06F 015/70
EP 617815 A1	October 5, 1994	G	046	G06F 015/70
JP 07502353 W	March 9, 1995	N/A	018	G06T 007/00
EP 617815 B1	October 25, 1995	G	034	G06T 007/60

DESIGNATED-STATES: JP US AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE AT CH E
S FR GB IE IT LI NL SE AT CH ES FR GB IE IT LI NL SE

CITED-DOCUMENTS: EP 492633; US 4764681

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
DE 4141880C1	N/A	1991DE-4141880	December 18, 1991
ES 2081204T3	N/A	1993EP-0900103	

December 17, 1992		
ES 2081204T3	Based on	EP 617815
N/A		
WO 9312503A1	N/A	1992WO-EP02935
December 17, 1992		
EP 617815A1	N/A	1992WO-EP02935
December 17, 1992		
EP 617815A1	N/A	1993EP-0900103
December 17, 1992		
EP 617815A1	Based on	WO 9312503
N/A		
JP07502353W	N/A	1992WO-EP02935
December 17, 1992		
JP07502353W	N/A	1993JP-0510637
December 17, 1992		
JP07502353W	Based on	WO 9312503
N/A		
EP 617815B1	N/A	1992WO-EP02935
December 17, 1992		
EP 617815B1	N/A	1993EP-0900103
December 17, 1992		
EP 617815B1	Based on	WO 9312503
N/A		

INT-CL_(IPC): G01B011/24; G06F015/70 ; G06K009/00 ; G06K009/68 ;
G06T007/00 ; G06T007/60

ABSTRACTED-PUB-NO: DE 4141880C

BASIC-ABSTRACT: The image signals from the video camera (3) are compared in a window comparator (17a,17b,17c). The number of points in a region, lying between the threshold values, is determined and stored in an element of a memory **matrix** (23) for a reduced **image,** the position of an element in the memory **matrix** corresp. with the position of the region in the output **image**.

The reduced image is scanned by a **mask** and the elements determined with a content exceeding a set amount. These are given the same index, repeated for all the elements, and then for different indices.

USE/ADVANTAGE - Objects can be classified easily according

to size. Suitable
for hospital and clinical applications in connection with the diagnosis of
illnesses.

ABSTRACTED-PUB-NO: EP 617815B
EQUIVALENT-ABSTRACTS: Process for the automatic recognition of objects, in
particular of irregularly and/or discontinuously formed objects such as for
example cell clusters, in which an initial **image,** having n.m **image** points, is
taken of the object region to be investigated by means of a video camera,
characterised by the following further process steps; (a) the **image** point
signals provided by the video camera (3) are compared with an upper and a lower
threshold value in a window comparator (17, 17a, 17b, 17c); (b) in
correspondence with the output signal of the window comparator, the **number of**
image point elements lying between the threshold **values is determined for a**
region (a.b) of the initial image, and this number is stored in an element of a
memory **matrix** (23) for a reduced **image, the position** of each individual **matrix**
element in the memory **matrix** (23) corresponding to the **position of the**
associated region (a.b) in the output **image** of the video camera (3); (c) the
reduced **image** held in the memory **matrix** (23) is scanned with a **mask,** the
central element of the **mask** being laid over an element of the reduced **image the**
content of which exceeds a predetermined value SW, and then those **matrix**
elements within the **mask** whose contents also exceed the predetermined value SW
are detected and are considered as belonging together with the initial **image**
element and are allocated the same index 1, this procedure being repeated for
each **matrix** element of the memory **matrix** (23) of the reduced **image whose**

content exceeds the predetermined value and which has not
yet been allocated an
index in a preceding scanning.

CHOSEN-DRAWING: Dwg.6/19 Dwg.1/19

TITLE-TERMS:
AUTOMATIC RECOGNISE OBJECT IRREGULAR CELL CLUSTER SUPPLY
WINDOW COMPARATOR
UPPER LOWER THRESHOLD VALVE IMAGE POINT SIGNAL VIDEO CAMERA

DERWENT-CLASS: S05 T04

EPI-CODES: S05-C09; T04-D07C;

SECONDARY-ACC-NO:
Non-CPI Secondary Accession Numbers: N1993-059746

DERWENT-ACC-NO: 1999-236938
DERWENT-WEEK: 199920

TITLE: Information compression encryption apparatus - decides initial value of symbol surface based on encryption decided with data input from user during compression

PATENT-ASSIGNEE: FUJITSU LTD[FUIT]

PRIORITY-DATA: 1997JP-0221340 (August 18, 1997)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
JP 11065437 A	March 5, 1999	N/A	011	G09C 001/00

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
JP11065437A	N/A	1997JP-0221340	August 18, 1997

INT-CL_(IPC): G06F012/14; G09C001/00 ; H03M007/30 ; H04L009/36

ABSTRACTED-PUB-NO: JP11065437A

BASIC-ABSTRACT: NOVELTY - An initialization unit decides initial value of symbol surface **obtained** from a symbol tree based on decided encryption. The symbol surface with initial value and the symbol surface updated by the encryption of input data are stored in memory. DETAILED DESCRIPTION - Encryption of data is decided with the data input by user during compression. The time for updating the symbol tree midway through an encoding is also decided.

USE - For **encrypting character code, vector information,**

image using computer.

ADVANTAGE - As data encryption is performed while data compression, data is secured. Since the encryption is decided from the password input from a user, processing of encryption becomes simple. Compression efficiency is not reduced as rearrangement of symbol tree decides initial value without changing bit length of character. DESCRIPTION OF DRAWING(S) - The drawing explains the information compression encryption apparatus.

CHOSEN-DRAWING: Dwg.1/19

TITLE-TERMS:
INFORMATION COMPRESS ENCRYPTION APPARATUS DECIDE INITIAL VALUE SYMBOL SURFACE BASED ENCRYPTION DECIDE DATA INPUT USER COMPRESS

DERWENT-CLASS: P85 T01 U21 W01

EPI-CODES: T01-H01C2; U21-A05A2; W01-A02A; W01-A05; W01-A05A;

SECONDARY-ACC-NO:
Non-CPI Secondary Accession Numbers: N1999-176210

L Number	Hits	Search Text	DB	Time stamp
1	233	((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 ((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)))	USPAT	2002/05/19 18:04
2	214	(((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 ((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)))) AND (access$4 OR obtain$6 OR unlock$4)	USPAT	2002/05/19 18:05
3	12	((((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 ((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)))) AND (access$4 OR obtain$6 OR unlock$4)) AND (((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7) NEAR3 (key$1 OR code$1 OR value$1)) WITH ((grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1) AND (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6)))	USPAT	2002/05/19 18:50
4	281725	(encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))	USPAT	2002/05/19 18:51
5	19464	((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))	USPAT	2002/05/19 18:53
6	8938	(((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))	USPAT	2002/05/19 18:54

7	7123	((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))	USPAT	2002/05/19 18:57
8	312	(((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((ASCII) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR numeric$4 OR alphabet$4 OR alphanumeric$4 OR typograph$6))	USPAT	2002/05/19 19:00

9	3178	(((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))	USPAT	2002/05/19 19:01
10	188	((((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((ASCII) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR numeric$4 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))	USPAT	2002/05/19 19:07

11	1121	(((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6) WITH (sequen$5 OR pattern$4 OR position$4 OR spatial$2 OR spac$3 OR locat$4) WITH (graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5))	USPAT	2002/05/19 19:11

12	79	(((((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((ASCII) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR numeric$4 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND (((((((encrypt$4 OR encipher$4 OR scrambl$4 OR crypto$7 OR mask$4 OR disguis$4 OR hid$4 OR steganograph$6 OR watermark$4 OR (water ADJ1 mark$4))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) NEAR5 (key$1 OR code$1 OR value$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (grid$1 OR matrix OR matrices OR array$1 OR vector$1 OR row$1 OR column$1))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((graph$5 OR imag$5 OR pictu$5 OR picto$5 OR photograph$5) WITH (relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6))) AND ((relat$6 OR associat$6 OR correspond$6 OR represent$6) WITH (letter$1 OR character$1 OR number$1 OR numeral$1 OR alphabet$4 OR alphanumeric$4 OR typograph$6) WITH (sequen$5 OR pattern$4 OR position$4 OR spatial$2 OR spac$3 OR locat$4) WITH (graph$5 OR imag$5 OR	USPAT	2002/05/19 19:11

DOCUMENT-IDENTIFIER: US 5793871 A
TITLE: Optical encryption interface

---------- KWIC ---------

ABPL:
An analog optical encryption system based on phase scrambling of two-dimensional optical **images and holographic transformation for achieving large encryption keys and high encryption** speed. An enciphering interface uses a spatial light modulator for converting a digital data stream into a two dimensional optical image. The optical image is further transformed into a hologram with a random phase distribution. The hologram is converted into digital form for transmission over a shared information channel. A respective deciphering interface at a receiver reverses the encrypting process by using a phase conjugate reconstruction of the phase scrambled hologram.

BSPR:
Data encryption techniques can be used to increase the security in data exchange and transfer over a shared transmission channel. In its simplest form, data encryption uses a "key" based on a particular algorithm to change the sequence of a package of data that contains a piece of confidential information ("plaintext") so that the data is enciphered or "scrambled" into an form that appears to have no correlation with the embedded confidential information ("ciphertext"). An unauthorized user, who does not have the knowledge of either the encryption method (e.g., the encryption algorithm) or the key formed based on the encryption method, cannot easily decode the

information. An authorized user recovers the embedded information in the scrambled data by using a "key" that is constructed based on the encryption method. Therefore, even if the unauthorized user **obtains** the scrambled data, the knowledge of both of the encryption method and the particular key is needed to decrypt the confidential information embedded therein.

BSPR:
One well-known encryption system is the Data Encryption Standard (DES) adapted in 1977 by the National Bureau of Standards. This is a secret-key cryptosystem to exploit confusion and diffusion techniques, allowing acceptable security using key lengths as short as 64. The **number of keys in cryptosystems** based on the DES can be as many as 512 keys with the current computational power. However, increased key lengths "cost" significant delays in transmitting and receiving the encoded information.

BSPR:
One aspect of the present invention is to achieve optical encryption keys up to and greater than 10.sup.6 keys to enhance the security. This is a difficult implementation for the prior-art systems. Such a large **number of encryption keys** is possible because of the unique optical analog technique in accordance with the present invention.

BSPR:
It is another aspect of the present invention to insure fast enciphering and deciphering of a large encryption key that are rarely **obtainable** with the prior-art systems. The preferred embodiments implement this by using the high-speed optical reconstruction of a data-bearing hologram and the capability of parallel processing of optical data processing devices.

DEPR:
The resolution of the 2D image that can be enciphered and deciphered will be
the total **number** of modes that can be handled by the waveguiding medium N.sub.w
.times.M.sub.w, which also represents the effective length of the **encryption**
key size that can be handled by the optical encryption. Preferably, the
dimensions of the waveguiding medium may be chosen so that it can support many
CCD array. If each pixel at the CCD and the SLM has an 8-bit grey scale
resolution, G, the real key size is thus determined by the resolution of the
CCD, N.times.M.times.G. Similarly, the effective block size is determined by
the spatial and grey scale resolution, G, of the SLM (i.e. N.times.M.times.G).
If N=M=128, this embodiment allows one to easily work with both key and block
sizes that exceed 100,000-bits in length. In addition, the polarization and
the wavelength of the light source used to encrypted the image may also be
required for deciphering. If there are P=36 different possible polarization
orientations, the **number** of possible wavelengths is W=10, and N=M=128, the
corresponding optical **encryption key** is thus on the order of
(M.times.N).times.P.times.W=4.6.times.10.sup.6. Such a large encryption key is
possible according to the present invention because of the intrinsically
parallel nature of optical processing in both encoding and decoding large
blocks of data in a single step.

DEPL:
where .theta.(x,y) represents the scrambled phase component in a plane
perpendicular to direction of k.sub.2. This scrambled phase .theta.(x,y)
causes the image imprinted in the optical beam 211 to be unintelligible or have
an appearance that has no correlation with the unscrambled

image at the SLM
206. In effect, the data has been encrypted optically by the phase scrambling
device 210. An intruder who **obtains** a copy of the scrambled data converted
from the beam 211 cannot retrieve the information embedded therein by analog
techniques without having the information of the scrambled phase .theta.(x,y)
and corresponding hardware to unscramble the phase.

CLPV:
an encryption device operable to cause said electrical signal **array to be**
encrypted according to a key to form an encrypted electrical signal **array**.

CLPV:
an encryption device operable to cause said first electrical signal **array to be**
encrypted according to an encryption key to form a first encrypted electrical
signal **array,** wherein said first encrypted electrical signal **array** is converted
into an encrypted serial digital data stream.

CLPV:
encrypting said second spatial **array** of electrical signals by using a first **key**
to form an encrypted second spatial **array** of electrical signals; and

DOCUMENT-IDENTIFIER: US 5946414 A
TITLE: Encoding data in color images using patterned color modulated image regions

---------- KWIC ---------

ABPL:
Message values included in a set of valid message **values that constitute a coding scheme are each encoded in an image** region, called an encoded signal block, composed of a spatially arranged pattern of colored sub-regions. The colored sub-regions have color values produced by modulating a reference color value by a color change quantity expressed as a color space direction in a multi-dimensional color space such that the average color of all of the sub-region colors is the reference color. There is a unique pattern of color-modulated sub-regions for each valid message value in the coding scheme.
In one embodiment, the color space direction is computed to be simultaneously detectable by a digital image capture device such as a scanner and substantially imperceptible to a human viewer, so that the embedded data represented by the pattern of color modulations are visually imperceptible in the encoded signal block. When the reference color is determined to be the average color of an image region in an original color image, the encoded signal block may replace the image region in the original image, producing an encoded image version of the original image having little or no image degradation. In this case, the original image colors become carriers of the encoded data.
Signal blocks may be arranged to encode data in only one dimension in an **image,**

which allows for less complex decoding algorithms, or in a two dimensional array or grid-like structure, which allows for a high encoded data density rate.

BSPR:
Bar codes are a well-known category of document or image marking techniques that have as their primary goal to densely encode digital information in a small image space without regard to how visible the encoded information is to a human viewer, and with the intent to reliable decode the information at a later time. Bar code images are typically attached to other objects and carry identifying information. U.S. Pat. No. 4,443,694, entitled "Multilevel Bar Code Reader" discloses a bar code reader for decoding a bar code using at least three levels of darkness. The bar code that encodes data consists of a plurality of bars, each of which has a particular level of darkness. The sequence of bars encodes a particular data string in a printed format. It is disclosed that in a particular embodiment of the invention, the transition from one darkness level to another second darkness level is indicative of the encoding of a predetermined value of a binary string. Each transition from bar to bar is translated into its appropriate dual set of bit strings to divulge the final binary string. In this embodiment five levels of darkness are utilized in the bar code, with each level having associated with it a certain degree of darkness including white, white-gray, gray, gray-black, and black.

BSPR:
U.S. Pat. No. 5,619,026, entitled "Grayscale Barcode Reading Apparatus System Including Translating Device for Translating a Pattern Image into a Sequence of

Bar Widths and Transition Directions," discloses a system for verifying an object of interest that includes a grayscale one-dimensional bar pattern coupled to the object. The grayscale pattern includes vertical stripes of varying brightness and width, and is disclosed as being a **hidden** pattern. It is disclosed that the use of grayscale bar codes differs from standard practice which uses binary patterns. Decoding relies on detecting distinct transitions between gray scales at the edges of the bars.

BSPR:
Two-dimensional (2D) bar codes encode data in both the height and width of an encoded bar **code image,** and so store considerably more information than a linear, one-dimensional (1D) bar code. It is estimated that over a thousand alphanumeric characters can be placed in a single 2D bar code symbol the size of a large postage stamp. 2D bar codes typically have one of two designs: a stacked, or multi-row linear bar code, and a matrix or dot type bar code. The matrix type of 2D bar code is usually square and made up of a grid of small square cells which can be black or white. PDF417 is an example of a stacked 2D bar code. PDF417 has a very high data capacity and density: each symbol can code up to 2725 bytes of data at a density of about 300-500 bytes per square inch. DataMatrix is an example of a 2D matrix-type bar code that contains up to 2,335 characters per symbol. Symbols typically have 400-500 characters per square inch. Maxicode is an example of a dot-type 2D bar code that uses 888 data-carrying circular cells arranged around a bullseye; approximately 100 alphanumeric characters can be encoded in a square inch. Additional information on 2D bar codes may be found, for example, in an article by

Johnston and Yap entitled "Two Dimensional Bar Code as a Medium for Electronic
Data Interchange," Monash University (Clayton, Victoria) available as of the
date of filing at
http://www.bs.monash.edu.au/staff/johno/BARCOPAW.html.

BSPR:
In an article entitled "A Flexibly Configurable 2D Bar Code", available as of
the date of filing at
http://www.paperdisk.com/ibippapr.htm, Antognini and Antognini disclose a 2D symbol technology called PaperDisk.TM. that represents
data by means of what is termed a "spot" or "cell". A spot is a typically
rectangular array of dots, or printed pixels, laid down by a printer to
represent a bit being "on". It is separated from adjoining spots (or places
they might occupy) by designated vertical and horizontal distances. These
distances are measured in terms of (typically) integral numbers of dots. A
cell is a region allocated to a given potential spot. That is, it includes the
spot itself (where the bit value calls for a spot) and extends halfway tot he
edges of neighboring potential spots. Clocking features, called "markers" are
rectangular arrays of dots arranged in vertical strips throughout a pattern.
All encoded data plus landmarks and meta-information about the encoded
information are collectively referred to as a data tile. Decoding proceeds by
first finding a landmark, from which a preliminary estimate can be made of the
scale and orientation of the features in the image, with the goal of finding
the meta-information. When the meta-information is found it is decoded to
produce data format parameter values for the data portion that follows. FIG. 2
illustrates a full data tile as a black and white **image** of a large **number** of
small, rectangular dark marks. It would appear, then, from

the disclosure that
the PaperDisk.TM. technology is intended to produce an encoded image in which
the encoded data is visible to a human viewer.

BSPR:
A particularly well-known area of image marking is known as digital
watermarking, which is typically applied to a graphic or photographic image. A
successful digital **watermarking** technique is concerned with the factors of
robustness and minimizing image changes, and so is designed to simultaneously
produce an embedded signal that is imperceptible to a human viewer so as not to
diminish the commercial quality and **value of the image being watermarked,** while
also producing an embedded signal that is resistant to tampering, since removal
of the embedded signal defeats the identification purpose of **watermarking**. A
successful **watermarking** technique is typically designed so that attempts to
remove the embedded signal cause degradation of the image sufficient to render
it commercially less valuable or worthless. Because the factors of minimizing
image change and encoded data robustness are so crucial to successful digital
watermarking techniques, the goal of achieving a high data density rate is
typically sacrificed in these techniques.

BSPR:
PCT International Application WO 95/14289 discloses a signal encoding technique
in which an identification code signal is impressed on a carrier to be
identified (such as an electronic data signal or a physical medium) in a manner
that permits the identification signal later to be discerned and the carrier
thereby identified. The method and apparatus are characterized by robustness
despite degradation of the encoded carrier, and by holographic permeation of

the identification signal throughout the carrier. The embedding of an imperceptible identification code throughout a source signal is achieved by modulating the source signal with a small noise signal in a coded fashion; bits of a binary identification code are referenced, one at a time, to control modulation of the source signal with the noise signal. In a disclosed preferred embodiment, an N-bit identification word is embedded in an original image by generating N independent random encoding images for each bit of the N-bit identification word, applying a mid-spatial-frequency filter to each independent random encoding image to remove the lower and higher frequencies, and adding all of the filtered random **images together that have a "1" in their corresponding bit value** of the N-bit identification word; the resulting image is the composite embedded signal. The composite embedded signal is then added to the original image using a formula (Equations 2 and 3) that is based on the square root of the innate brightness value of a pixel. Varying certain empirical parameters in the formula allows for visual experimentation in adding the composite identification signal to the original image to achieve a resulting marked image, which includes the composite identification signal as added noise, that is acceptably close to the original image in an aesthetic sense.

BSPR:
Cox, Kilian, Leighton and Shamoon, in NEC Research Institute Technical Report No. 95-10 entitled "Secure Spread Spectrum **Watermarking** for Multimedia," disclose a frequency domain digital **watermarking** technique for use in audio, image, video and multimedia data which views the frequency domain of the data

(image or sound) signal to be **watermarked** as a communication channel, and correspondingly, views the **watermark** as a signal that is transmitted through it. In particular with respect to **watermarking** an N.times.N black and white image, the technique first computes the N.times.N DCT of the image to be **watermarked**; then a perceptual **mask** is computed that highlights the perceptually significant regions in the spectrum that can support the **watermark** without affecting perceptual fidelity. Each coefficient in the frequency domain has a perceptual capacity defined as a quantity of additional information that can be added without any (or with minimal) impact to the perceptual fidelity of the data. The **watermark** is placed into the n highest magnitude coefficients of the transform matrix excluding the DC component. For most images, these coefficients will be the ones corresponding to the low frequencies. The precise magnitude of the added **watermark** signal is controlled by one or more scaling parameters that appear to be empirically determined.
Cox et. al note that to determine the perceptual capacity of each frequency, one can use models for the appropriate perceptual system or simple experimentation, and that further refinement of the method would identify the perceptually significant components based on an analysis of the image and the human perceptual system. Cox et. al also provide what appears to be a detailed survey of previous work in digital **watermarking**.

BSPR:
Data glyph technology is a category of embedded encoded information that is particularly advantageous for use in image applications that require a high density rate of embedded data and require the embedded data to be robust for

decoding purposes. However, data glyph encoding produces perceptible image changes which may be able to be minimized so as to be inconspicuous, or even surreptitious, in particular types of images. Data glyph technology encodes digital information in the form of binary 1's and 0's that are then rendered in the form of distinguishable shaped marks such as very small linear marks. Generally, each small mark represents a digit of binary data; whether the particular digit is a digital 1 or 0 depends on the linear orientation of the particular mark. For example, in one embodiment, marks that are oriented from top left to bottom right may represent a 0, while marks oriented from bottom left to top right may represent a 1. The individual marks are of such a small size **relative** to the maximum resolution of a black and white printing device so as to produce an overall visual effect to a casual observer of a uniformly gray halftone area when a large **number** of such marks are printed together in a black and white **image** on paper; when incorporated in an **image** border or **graphic,** this uniformly gray halftone area does not explicitly suggest that embedded data is present in the document. A viewer of the image could perhaps detect by very close scrutiny that the small dots forming the gray halftone area are a series of small marks that together bear binary information. The uniformly gray halftone area may already be an element of the image, or it may be added to the image in the form of a border, a logo, or some other image element suitable to the nature of the document.

BSPR:
Some types of 2D bar code technology encode data at a high density rate but none are intended to produce encoded data that is substantially imperceptible

in an encoded image. Data glyph technology, which also supports a high data density encoding rate, is also not designed to produce encoded data that is substantially imperceptible in an encoded image, although data glyphs may happen to be very unobtrusive in an encoded image as a result of where they are placed. The technology disclosed in the '885 patent requires that the differently colored patches produce an average color that effectively **hides** them from view; in order to decode the message value in a color patch of a first color, it is necessary to determine the second color used to encode a different data **value, and also to determine the average color of the image** region in which data is encoded in order to establish the color space relationship between the two colors.

BSPR:
The image encoding technique of the present invention is motivated by the need to reliably encode information at a high density rate in an image, and in particular in graphic or photographic images, without any perceived image degradation or distortion. The technique has as its premise that existing color regions in an original color image may successfully function as the carrier of encoded information in the form of color differences, or color modulations, when the color modulations are rigorously designed to ensure reliable decoding and recovery of the embedded information. The invention makes use of a plurality of data structures, referred to herein as "signal blocks", each having a spatial pattern of color modulation unique to all other signal blocks and that encodes one of the possible values of a coding scheme that the information may assume. When a color value is added to a signal

block, an "output signal block color **image**," or just "output signal block," is produced by modulating, or varying, a reference color defined by a **vector** in a multi-dimensional color space by a certain magnitude along a color space direction (**vector**). The color space direction may be selected to ensure that the individual colors within an output signal block are not perceptible to a human viewer of the image and that the output signal block itself has an overall perceived average color of the reference color. When an existing color in an input region of the original color image is provided as the reference color, the color space direction is determined, and a color modulated output signal block is produced to replace the input region in the original image. The specific pattern of the color modulations of a signal block is determined by a vector-valued function that controls the spatial location, and therefore the pattern, of the modulated colors within the output signal block itself. In the illustrated embodiment, defining orthonormal basis functions allows for specifying uniquely patterned signal blocks. Each uniquely patterned signal block is assigned one of the valid values in the coding scheme of the data to be encoded. In one implementation, a long sequence of output signal blocks that encode a message replaces **image** regions according to some predetermined **image** order such as, for example, from the top left of an **image** to the bottom right of an **image** along a horizontal axis, thus forming a **grid** of output signal blocks over the **image**.

BSPR:
In another implementation, the color space direction and the magnitude of the color changes within the patterned output signal blocks may be computed using

the technique disclosed in U.S. patent application Ser. No. 08/956,326, entitled "Determining An Optimal Color Space Direction For Selecting Color Modulations" (hereafter, the '326 patent application.) The invention of the '326 application mathematically models the determination of a color space direction as an optimization problem and uses models of human perception and scanner response that produce quantitative measurements of color changes. A given input color and a direction, or vector, in color space define a second color positioned along the vector. A quantitative color difference between the input color and the second color is measured both by the human perception model and the scanner response model. When the measurable color difference is simultaneously minimally perceptible to a human viewer and maximally detectable by a digital **image** capture device such as a scanner, the **vector** defined by the input color and the second color is defined to be the optimal color space direction for the respective input color. The technique in the '326 application is premised on the observation that the color modulation could be derived using any one of a number of color space directions centered at the input color but that there is an optimal color space direction that satisfies the perception and detection criteria.

BSPR:
When the pattern of color modulations varies in two dimensions, decoding is more complex but two-dimensional signal block encoding can achieve a highly encoded data density rate. In effect, the output signal blocks blanket the **image** in a two-dimensional **grid** and can be made as small as is appropriate within the constraints of the decoding process and the marking technology used

to produce an encoded **image** on a marking medium. The two-dimensional **grid**
embodiment of the technique for embedding data is particularly effective in
graphic and photographic images for achieving a high information encoding
density rate with little or no perceived **image** degradation.

BSPR:
Therefore, in accordance with one aspect of the present invention, a method is
provided for operating a processor-controlled machine to produce an output
color image having at least one message data item indicating data encoded
therein. The machine includes a processor and a memory device for storing data
including instruction data the processor executes to operate the machine. The
processor is connected to the memory device for accessing and executing the
instruction data stored therein. The method comprises obtaining a message data
item indicating a message value that is one of an expected set of valid message
values in a predetermined coding scheme, and selecting a modulation pattern
data structure representing the message value. The selected modulation pattern
data structure is one of a plurality of modulation pattern data structures each
uniquely representing one of the valid message values in the coding scheme.
Each modulation pattern data structure defines dimensions of an output signal
block color image and includes a plurality of at least two different data
values spatially arranged in a pattern indicating image locations in the output
signal block color image of at least two colors; the two colors are produced by
applying a color difference quantity to an unspecified reference color. The
method further comprises obtaining an output color value as the unspecified
reference color and obtaining the color difference quantity using the output

color value. Then an output signal block color **image is produced using the output color value,** the color difference quantity and the selected modulation pattern data structure. The output signal block color image has the dimensions indicated by the modulation pattern data structure and includes a spatially arranged pattern of color modulated **image regions having color values** produced by modulating the output color value by the color difference quantity, subject to the requirement that the output color value be an average color of all of the color **values of the color modulated image** regions. An output color image is produced that includes the output signal block color image as an image region therein.

BSPR:
In another aspect of the invention, obtaining the color difference quantity includes using the output color value to compute, in a multi-dimensional color space, a color space direction and associated color modulation magnitude that together define an additive change in the output color value, and modulating the output color value by the color difference quantity includes generating the color values of the spatially arranged pattern of color modulated **image regions by varying the output color value** by the additive change scaled by scaling data included in the modulation pattern data structure.

BSPR:
In still another aspect of the invention, the color difference quantity is a color space direction and associated color modulation magnitude that is computed so that the color **values of the color modulated image** regions included in the output signal block color image are simultaneously capable of being detected by a digital image capture device and are visually

substantially
imperceptible to a human viewer of the output signal block color image. The spatially arranged pattern of color modulated image regions in the output signal block color image are thereby visually substantially imperceptible to the human viewer.

BSPR:
In accordance with yet another aspect of the present invention, a method is provided for operating a processor-controlled machine to encode a plurality of message data items in an encoded color image version of an input color image so that the message data items are visually substantially imperceptible to a human viewer. The machine includes a processor and a memory device for storing data including instruction data the processor executes to operate the machine. The processor is connected to the memory device for accessing and executing the instruction data stored therein. The method comprises receiving an input color image data structure including a plurality of subregions and obtaining a plurality of ordered message data items having a predetermined order, each indicating a message value that is one of an expected set of valid message values in a predetermined coding scheme. The method further includes, for each ordered message data item, in the predetermined order thereof, producing an output signal block color image, including selecting a signal block data structure representing the message value of the message data item. A selected signal block data structure is one of a plurality of signal block data structures each uniquely representing one of the valid message values in the coding scheme. Each signal block data structure defines size dimensions of an output signal block color image and includes variable data

indicating a color difference quantity. Each signal block data structure further includes scaling data indicating a spatially arranged modulation pattern specifying image locations in the output signal block color image of scaled color difference quantities produced by applying the scaling data to the color difference quantity. Producing an output signal block color **image further includes determining an input color value** of one of the subimage regions of the input color image, obtaining the color difference quantity using the input color value, and producing an output signal block color **image using the input color value,** the color difference quantity and the selected signal block data structure. The output signal block color image has a spatially arranged pattern of color modulated **image regions each having a color value** produced by modulating the input color value by the color difference quantity according to the scaling data indicating the modulation pattern, subject to a requirement that the input color value be an average color of all of the color **values of the color modulated image** regions. Then the subimage region in the input color image is replaced with the output signal block color image. The encoded color image version of the input color image is produced by replacing the subimage regions of the input color image with the output signal block color images in the predetermined order of the ordered message data items, and is perceived by a human viewer to be substantially identical in appearance to the original color image.

DRPR:
FIG. 41 schematically illustrates the components of producing an output signal block color **image** including multiplying a unique spatial

pattern of scalars by a color space direction **vector** and adding an input reference color;

DRPR:
FIGS. 44 and 45 graphically respectively illustrate the operation of correctly and incorrectly synchronizing a signal **grid** framework to an encoded **image** to locate received signal cells during decoding;

DEPR:
FIG. 1 is a block diagram of the image encoding technique showing operations 200 and 300 and illustrating the input and output data structures that the two operations require. These operations and data structures are briefly introduced here and discussed in more detail below. Operation 200 produces a message image 70, M, from input data 20 denoted in FIG. 1 as message, m, that is to be encoded in an original color image 40. Message, m, includes message values that are instances of valid message values in a coding scheme, such as a binary coding scheme. Operation 200 uses data structures 30, referred to hereafter as "signal blocks", that are specifically designed to encode message m. There is a uniquely patterned signal block for every valid value in the coding scheme. Operation 200 defines the uniquely-patterned signal blocks 30 used for encoding and arranges them according to the message, m, forming a collection of signal blocks that is referred to as message image 70. Each signal block 30 defines the size dimensions of an output signal block color image produced as a result of the encoding operation, and includes variable data indicating a color difference quantity. Each signal block 30 also includes scaling data indicating image locations in the output signal block image of a pattern of constituent image regions, also

referred to herein for conciseness as "subregions." The subregions in the output signal block have at least two different color **values and occur in a unique image** location pattern defined by the signal block. Operation 300 additively combines message image 70 with input color (carrier) image 40, determining the colors of the component subregions of each output signal block using a color difference quantity, the signal blocks arranged in message image 70 and an input color from image 40. Once the colors for each output signal block have been determined, the final encoded image 80, denoted as image, E, is complete.

DEPR:
In FIG. 2, the different color modulations of the subregions are denoted by vector notation .+-..delta., which signifies that the color modulation, or change, in the color value of each subregion occurs along a vector specifying both a color space direction and associated color modulation magnitude in a multi-dimensional color space. The color modulations have the requirement that the overall mean of the color difference quantities in a signal block is 0. That is, while the individual subregions denote different color modulations, these color differences produce no overall change in color in an output signal block, once the color modulations are applied to a reference color. Thus, an output signal block, which is composed of **image regions having color values** produced by modulating a reference color according to the color modulation pattern, will appear to have an average color of the reference color; the color modulated image subregions will not be perceptible to a human viewer and will be integrated by the human eye into the mean color of the reference color. How the color space direction and the color modulation of the

subregions are selected is described below in the discussion accompanying FIGS. 9 and 10.

DEPR:
The flowchart of FIG. 3 illustrates an embodiment of operation 200 of the image encoding technique. Operation 200 assumes that there is a known color image 40 (FIG. 1), referred to as the carrier image, into which input message data 20, also referred to as message m, is to be encoded. Message data 20 is composed of a string of message data items each indicating one of a set of valid message values in a coding scheme. Message data 20 is not restricted in any way as to the nature of the information it may convey, and may, for example, represent **character** symbols in a language using **ASCII** or UNICODE **character** encoding, or the compressed or **encrypted** form of such symbols. Message data 20 may also include error correction codes and any other such data as might be needed to facilitate decoding. Message data 20 may indicate binary data in the form of "0" and "1" symbols, or may indicate a set of values that define another coding scheme. Message data 20 may also indicate instruction data of the type used to operate a processor that controls a machine having the configuration of machine 100 in FIG. 47. Examples of such machines include a computer, printer, scanning device or facsimile device, or a machine that combines these functions. By way of further clarification as to terminology, the term "indicates" as used in this description and in the claims has several meanings, which can be determined in a particular instance by the context of its use. An item of data is said to "indicate" a thing, an event, or a characteristic when the item has a value that depends on the existence or occurrence of the thing,

event, or characteristic or on a measure of the thing, event, or characteristic. A first item of data "indicates" a second item of data when the second item of data can be obtained from the first item of data, when the second item of data can be accessible using the first item of data, when the second item of data can be obtained by decoding the first item of data, or when the first item of data can be an identifier of the second item of data.

DEPR:
Message data 20 is received in box 210. In this illustrated embodiment, the output signal blocks carrying the encoded data are arranged in the encoded **image** in a two-dimensional **array**. The message data items of message data 20 are arranged in a two-dimensional (2D) message **array** having the same size dimensions as carrier **image** 40. FIG. 4 shows an example of message array 22, where the message "001010011" has been arranged in a 3.times.3 array, with the message data items starting in the upper left corner of the array and ending in the lower right corner. Message array 22 is an example only; the message data items may be arranged in an array in any predetermined order. Retuning now to FIG. 3, a uniquely-patterned signal block is defined for each permitted message data value in the coding scheme, in box 240, as described above in the discussion accompanying FIG. 2. For each message data item in message **array** 22, the signal block that represents the value indicated by the message data item is selected, and all selected signal blocks are spatially arranged, in box 280, into an **image,** called the message **image** 74, M. Message **image** 74 in FIG. 4 illustrates the message **image** formed from spatially arranging the appropriate signal blocks for the data in message **array** 22. It can be

seen, for example,
that signal block 32 encodes the "0" value of message data item 23 in message
array 22 and signal block 33 encodes the "1" value of message data item 24 in
message array 22. At this point, message image 74 and the signal blocks
included therein have no colors associated with them.

DEPR:
One solution to images containing substantial image color variation is to
upsample the image by K to ensure that every location that is to have a signal
block is a smooth color. Upsampling, however, is not a requirement or
limitation of the encoding invention. Since each signal block in message **array**
74 has dimensions K.times.K color cells, the carrier **image** into which a message
is to be encoded may be first enlarged, or upsampled, in box 310 so that each
pixel in the carrier **image** becomes a small **image** region the size of a signal
block. This upsampled image is referred to as carrier image I'. This process
is illustrated in FIG. 6. Original color image 42 is a representative color
image shown with pixels of various colors represented by different
cross-hatching patterns. Original color image 42 is shown schematically as
having a simple composition for purposes of illustration so that the color
image encoding technique can be clearly illustrated. It is understood that a
color image of any type of pictorial complexity may be suitable for encoding
according to this technique. After upsampling operation 310, carrier image 49
is shown in FIG. 6 with enlarged image regions of the same colors. Image
regions 44 and 46 in image 49, which correspond to pixels 43 and 45 in image
42, are specifically called out as having different colors, denoted as c.sub.1
and c.sub.2.

DEPR:
FIG. 7 schematically illustrates the additive combining process of carrier **image** 49 and message **array** 74 carried out by box 320 of operation 300. FIG. 8 illustrates the combining process of a representative one of the signal blocks of message image 74 with its paired carrier image region. Signal block 32 is combined with carrier image region 44 having color c.sub.1. Resulting output signal block 82 has subregions of colors c.sub.1 +.delta. and c.sub.1 -.delta. arranged in the spatial pattern of signal block 32, with an overall mean perceived color of c.sub.1. FIG. 9 illustrates the combining process of a second one of the signal blocks of message image 74 with its paired carrier image region. Signal block 33 is combined with carrier image region 46 having color c.sub.2. Resulting output signal block 85 has subregions of colors c.sub.2 +.delta. and c.sub.2 -.delta. arranged in the spatial pattern of signal block 33, with an overall mean perceived color of c.sub.2.

DEPR:
FIG. 10 schematically illustrates the final encoded color **image** 88 showing the two-dimensional **array** 89 of output signal block color **images**. Encoded image 88 includes color-modulated output signal blocks 82 and 85 of FIGS. 8 and 9 respectively. Because message data 20 has been imperceptibly encoded via the color modulated signal blocks in carrier image 49 of FIG. 6, the colors of encoded image 88 are represented as being the same as those of carrier image 49, with various cross-hatching patterns. When a large message is densely encoded into a color **image,** the 2D signal blocks that encode the message form a **grid** that is superimposed over the original color **image**

when the message **image**
is additively combined in box 320 of FIG. 5.

DEPR:
Alternatively, rather than fixing the unit direction .delta. vector and magnitude .delta. of the modulation .delta. as constants, they may be optimally chosen according to a technique disclosed in copending U.S. patent application Ser. No. 08/956,326 (referenced earlier as the '326 application) for determining an optimal color space direction for a respective input color. The technique disclosed therein mathematically models the search for the color space direction as an optimization problem and uses models of human perception and scanner response that produce quantitative measurements of color changes. A given input color c and a second color positioned in a color space define a vector, or direction, in the color space. A quantitative color difference between color c and the second color is measured both by the human perception model and the scanner response model. When the measurable color difference is simultaneously minimally perceptible to a human viewer and maximally detectable by a digital **image** capture device such as a scanner, the **vector** defined by color c and the second color is defined to be the optimal color space direction for the respective input color c.

DEPR:
Note that the encoding technique may also encode data into gray scale images. In the gray scale implementation, all input colors are included in a set of gray scale colors that ranges from black to gray to white; that is, a color has equal R, G and B components. The color space direction is then known as the direction in color space that indicates the set of gray scale colors. The

color **values of the color modulated image** regions included in the output signal
block color image are therefore all included in the set of gray scale colors.

DEPR:
When a high encoded data density rate is not required in the encoding
application, a one-dimensional (1D) signal block may be used for encoding. In
a 1D signal block, the unique color-modulated pattern varies in only one
dimension linearly across the entire **image** such that there is essentially only
one **row or column** of message in the encoded **image**. Such encoding might permit
a simple, hand held digital **image** capture device to digitize and decode the
encoded **image** without the need to be concerned about **image** alignment and
skewing issues, and without the need for finding the locations of encoded
signal blocks in a 2D **grid**.

DEPR:
The encoding technique may be used in a wide variety of other implementations
as well. For example, rather than encode data into an existing original image,
a particular implementation may produce, or generate, an encoded image that is
comprised of only encoded output signal blocks. Such an image may be used as
an identifying image, such as a label, to be attached to an article or product.
In this case, an input color **value may not necessarily be obtained from another**
image, but may simply be input as a color value. The input color value may
also be a constant color value, producing a solid blue or red or orange image,
for example, or a multi-colored encoded image having an abstract composition.

DEPR:
There may be applications when it is not necessary to **hide** the color

modulations within each output signal block so that the requirements discussed above for computing a color space direction subject to the constraints of maximizing scanner detection and minimizing human perception may not be necessary. Any other suitable method may be used for determining color difference quantities to be applied to a reference color to produce color modulated image regions in the output signal block color image, subject to a requirement that the colors of the color modulated image regions all average to the reference color.

DEPR:
In the illustrated embodiment, a single color space direction is used for the color difference quantities for every location within an output signal block. The discussion below describes an implementation that allows for defining a substantial number of unique signal block patterns by allowing for two orthogonal color space directions. However, when it is not necessary to **hide** the color modulations within each output signal block, the color space direction may be a function of an image location in the output signal block, and so multiple color space directions may be used and they may be allowed to vary across the signal block.

DEPR:
The functions of the basis **vectors** can be graphically illustrated as "basis blocks"; this **graphical** representation is useful in order to illustrate how basis **vectors** are combined to form signal blocks. The functional characteristics of a signal block are simply that it be composed of at least two subregions that are differentiated by color. A further requirement is that a signal block has an average color difference of 0. That

is, the
area-weighted color average of all of the colors within an output signal block,
i.e., the sum of the colors weighted by their respective area within the output
signal block divided by the sum of the areas, is the reference color, c, used
to determine the color modulations. The basis functions must be defined to
comply with this requirement.

DEPR:
It may be desirable to increase the spatial frequencies of, and thereby reduce
the size of, the differently-colored subregions of constant color within a
signal block, subject to the physical limitations of the marking device.
Increasing the spatial frequency of the color-modulated subregions aids in
decreasing the visibility of the signal blocks to human viewers, thus
minimizing perceptual distortion in the image, without, in principle,
decreasing the signal to noise ratio. FIG. 40 illustrates by way of example
signal blocks 702 and 704 which are versions of signal blocks 32 and 33 of FIG.
2 each having a higher spatial frequency of color-modulated subregions. Signal
blocks 702 and 704 may be used in place of signal blocks 32 and 33 to encode
the message in message **array** 22 of FIG. 4 to produce a message **image,** M, in the
same manner that signal blocks 32 and 33 are used in FIG. 4.

DEPR:
The illustrations of signal blocks in the figures to this point (e.g., FIGS. 2,
27, 33, 34 and 39), show signal blocks to be unique patterns of color
modulations, .+-..delta.. Illustrating signal blocks in this manner blends
together the two inherent features of a signal block: the unique spatial
(scalar) modulation pattern that represents the message

data value, and the color space direction vector that controls the color modulation of a target, or reference, color. The color modulation causes an output signal block to have the target color as its overall mean color, thereby essentially **hiding** from view the unique modulation pattern that carries the message value. It is useful for further understanding of the invention to consider a second type of signal block illustration that explicitly separates the unique spatial modulation pattern of the signal block that carries the message value from the color modulation that is applied to a reference color for purposes of concealing the message. FIG. 41 shows modulation pattern data structure 333 as a unique spatial signal pattern 333 of scalars (e.g., .+-.1's). Modulation pattern 33 defines the size dimensions of an output signal block color image. The pattern of scalars indicate image locations in the output signal block color image of the modulated colors. The scalars are each multiplied by a unit color space direction **vector** 336, .delta., and amplitude (magnitude) scalar 338, .delta., and the result is then added to an input reference color c to produce output signal block 330 in an encoded **image**. An **array** of scalars, such as pattern 333, multiplied by a **vector,** such as unit color space direction 336, yields an **array of vectors** to which an input reference color c may be added to produce an **image** region in the form of output signal block 330. Output signal block 330 produced by the operation that uses modulation pattern 333 is equivalent to output signal block 85 of FIG. 9 produced by the operation that combines signal block 33 illustrated in FIG. 2 with a target color and modulates the colors in the signal block subregions accordingly.

DEPR:
Decoding the signal cells in an acquired color **image** also follows the classical **vector**-channel formulation of communications theory. The discussion of the mathematical framework of decoding the signal cells that follows assumes that the location and size of each signal cell has been previously determined and that the local average color has been subtracted off from each known signal cell, leaving only a series of received signal blocks with patterned color modulations. How the location and size of signal cells in an acquired image is determined is discussed in detail below. The explicit theoretical decoding problem is to determine, for each received signal block, which one of the set of valid signal blocks was used to modulate the original image in a particular local image region.

DEPR:
Let x.about.N(x,.sigma..sub.x.sup.2) denote that x is a Gaussian random variable (or process) of mean x and variance .sigma..sub.x.sup.2. Assume that pixel noise is zero-mean, uncorrelated, additive Gaussian noise, independent of signal blocks s.sub.i. The digital **image** capture device that produces the input **image** data to be decoded is a 2D **image** sensor **array** that produces a color **vector** c.epsilon. at each sensor location (pixel). Further assume that Gaussian noise is added in each color channel, and, for each pixel, is independent and identically distributed. This means that the noise component n is composed of 3K.sup.2 independent, identically distributed components: each element n[i,j] is a 3D noise vector whose 3 elements are random variables n.about.N(0,.sigma..sup.2).

DEPR:
Once the orientation and scale of the signal cells are known, it is necessary to determine their locations. It was noted earlier in the discussion of 2D signal block encoding that encoded signal blocks can be viewed as forming a **grid** that is superimposed over (e.g., additively combined with) the original color **image**. The "signal **grid**" is defined to be an **imaginary** framework of **grid** lines on which signal cells in acquired **image** 802 are centered. When a group of output signal blocks is placed edge to edge in an image, it is relatively straightforward to find the constant colored subregions in the acquired image but it is not straightforward to group the subregions into valid signal blocks. It cannot be assumed that any set of adjacent subregions that form the shape of an expected signal block is a valid signal block in the signal set, since the juxtaposition of signal blocks in an encoded image can form a variety of subregion patterns, as can be observed, for example, in message image M of FIG. 4. Thus, it is possible to be "out of phase" with the signal blocks due to a translational shift by the width of a subregion in either direction in the acquired image. A process critical to decoding operation 820, then, is to synchronize the signal cells with the signal grid. In general this is accomplished by analyzing all possible phase shifts of the signal grid to find one with the smallest number of invalid signal blocks. Even with errors and noise in the acquired **image,** the analysis process will detect a large **number** of invalid signal blocks when the signal **grid** is out of phase with the actual received signal blocks encoded in the acquired **image**.

DEPR:
Each signal cell in acquired image 802 is a valid signal

block in the signal
set with subregions that have colors modulated from the local color for that
image region in the original color image according to the unique signal block
pattern. For purposes of decoding acquired image 802, the local image color
for the region occupied by the signal cell can be viewed as noise. What is
essential to decoding is the pattern of the .+-..delta. (and, where
applicable, the .+-..mu.) modulations. Thus, once the locations and sizes of
the signal cells are known, the local average color for each image region
occupied by a signal cell is subtracted from the signal cell, leaving only a
received signal block with the pattern of color modulation. Once the signal
cells have been synchronized to the signal **grid,** and the local average color
subtracted off in each signal cell, the locations and sizes of each received
signal block in acquired **image** 802, denoted as data 842 in FIG. 43, are known
and available to the next part of the decoding process.

DEPR:
Signal block identification proceeds, in box 890. Each valid signal block in
the signal set is paired with a respective unique message value. Each
identified received signal block in acquired image 802 is correlated with each
of the valid and known signal blocks in the signal set that are expected to
appear in acquired image 802. As each signal block in acquired **image 802 is
identified, the respectively paired message value** it encodes may be determined
and stored in memory as part of the final recovered message 898.

DEPR:
When the scale and orientation of the acquired image are not known,
conventional image processing techniques for deskewing an

image and for finding image scale may be used. These conventional techniques typically require that an external document reference point, such as a border of the scanned image, be available. If such a reliable reference point or landmark is not available, it may be possible to find orientation and scale of the signal **grid** to analyze the high frequency components of the Fourier transform of the encoded acquired **image**. A strong peak of energy is expected at multiples of the signal grid frequency, in two orthogonal spatial directions. Finding the scale of the acquired image is critical to proper decoding, since the average color subtraction process requires that the dimensions of a signal cell be known. In the following discussion, assume that the scale of the acquired image is such that signal cells are K.times.K color cells.

DEPR:
The process of finding the signal **grid** in the acquired **image** proceeds as shown in the flowchart of operation 850 of FIG. 46. In box 852 a correlation image is computed for each unique signal block to be decoded in the acquired image. The correlation image indicates the correlation between (i.e., the inner product of) an image region centered at each location in the acquired image and a first unique signal block; there will be one correlation image for each unique signal block. In each of these correlation **images, there will be a high value in the locations where the acquired image** contains the signal block being correlated; in that same location in the other correlated **images, the value** will be low because the other signal blocks are not present. To find the locations of all of the signal blocks, an image called the max correlation image is created, in box 854, that contains, for each **image**

location, the
maximum value of all of the correlation images at that location. As noted earlier, signal cells are each centered at points on a signal grid whose spacing is K.times.K color cells. However, the position of the origin of the grid is unknown, so it is necessary to find which of the K.times.K "phase shifts" aligns the signal grid with the actual location of the centers of the signal cells. In box 860, an initial "phase shift," denoted as an offset from an initial starting position or origin in the max correlation **image,** is hypothesized, and each **grid** location in the max correlation **image** is tested for its correlation as a possible signal cell location in the hypothesized signal **grid**. A testing filter is designed to identify a correct signal grid phase shift and a test value is computed from all locations in the hypothesized signal grid. The testing in box 860 is repeated, in box 864, for all possible hypothesized phase shifts of the signal **grid** in the acquired **image**. The signal **grid** phase shift that best satisfies the expected test criterion is selected, in box 868, as the actual signal **grid** phase shift, producing the locations 842 of the signal cells in the acquired **image**.

DEPR:
A proposed testing filter used to locate the signal grid in the illustrated embodiment is described as follows. When a signal block is centered over a signal cell in the acquired **image, the value** of its inner product would be expected to be .+-.K.sup.2 .delta..sup.2. Therefore, subtracting K.sup.2 .delta..sup.2 from the **value in the max correlation image at all of the image** locations in the max correlation **image** that are true **grid** points (i.e., centers

of signal blocks) would result in low values for a correctly hypothesized **grid** position. Thus, the grid offset or phase shift that minimizes the sum of the squares of this difference over all grid locations locates the signal grid.

DEPR:
It should be noted that there is subtlety to synchronizing the signal **grid** with the received signal cells in the acquired **image** that may not be immediately apparent. For any given **image** region in the acquired **image,** in order to determine which signal block is there it is necessary to subtract off the local average color of the **image** region the signal block occupies, but the correct local average color for the **image** region can't really be accurately determined unless the signal **grid** is synchronized to valid signal blocks. A digital filter may be designed to compute and subtract the local image average, and correlate the result with the set of valid signal blocks.

DEPR:
This filter design and its use in synchronization operation 850 are described in a mathematical formulation as follows. Let S[m,n] be the acquired image. Let a[m,n] be a K.times.K kernel of constant value 1/K.sup.2 and symmetric about the origin. Let ##EQU7## be the correlation of S[m,n] with a[m,n]. Each point in S'.sub.K [m,n] is the average of the region centered at the corresponding point in S[m,n]. The signal block set s[m,n] is then correlated with S'.sub.K [m,n] to detect the presence of signal blocks in the acquired image, but because the signal blocks have zero mean color 0, this is equivalent to the correlation ##EQU8## When s.sub.l [i,j] is centered over a signal cell in acquired image S[m,n], the inner product of this region with the acquired

image is expected to have the value .+-.K.sup.2 .delta..sup.2. Thus, the signal **grid** can be synchronized with the signal cells in the acquired **image** by finding the offset (u,v), u,v.epsilon.[-K/2, +K/2] that minimizes ##EQU9## Note that correlation with kernels composed of constant rectangular subregions can be implemented efficiently using 2D cumulative sums of the acquired **image**.

DEPR:
Once the signal **grid** in the acquired **image** is located, the locations of the signal cells that occur in the **image** are known. It is then possible to identify which one of the signal blocks occurs in each of the signal cells. Identification of the signal cells assumes that, for each signal cell, the local average color has been subtracted from the signal cell, leaving a received signal block with subregions of color difference quantities in each grid location. To determine which one of the signal blocks in the signal set each received signal block is, the inner (dot) product of each valid signal block in the expected signal set with each received signal block in the acquired image is computed; the inner product of a received signal cell with each valid signal block in the signal set having the highest value identifies the valid signal block as the one encoded at that location. The message value paired with the identified signal block is then available for storing in a message data structure for constructing recovered message 898 (FIG. 43). Note that in most applications of the decoding technique, the signal cells will be arranged in an expected order in the acquired **image such that the message values,** when decoded from the received signal blocks and put in the expected order, form a message. The message values decoded from all

of the signal
cells, when arranged in the expected order, produce the message encoded in the
acquired image. However, there is no requirement for use of the decoding
technique that the signal cells be arranged in any expected order.

DEPR:
During execution of the instructions, processor 140 may access data memory 114
to obtain or store data necessary for performing its operations. For example,
when machine 100 is configured to perform operation 200 for producing a message
image given an input message, data memory 114 stores the image data structures
80 defining the signal blocks and data structure 20 indicating the input
message to be encoded, as well as message image data structure 70. Data memory
114 also stores upsampled carrier image data structure 116 that is to be
combined with message image data structure 70. Data memory 114 also stores
various other miscellaneous data such as data needed by color modulation
subroutine 320, if machine 100 is so configured. Similarly, when machine 100
is configured to perform decoding operation 800, data memory 114 stores data 30
defining the signal blocks that are expected to occur in an encoded **image, the
vector-valued** basis functions 894 that define the signal blocks, data 842
indicating signal cell locations and sizes that are produced as a result of
synchronization of the **grid** with signal cell centers, and recovered message
898. Data memory 114 further stores various other miscellaneous data needed by
decoding operation 800, when machine 100 is so configured.

DEPR:
A software implementation of an embodiment of the present invention was written
in Allegro Common Lisp version 4.3 (available from Franz in

Berkeley Calif.)
and in C code and executes on a Silicon Graphics
workstation model O2,
available from Silicon Graphics Incorporated of Mountain
View Calif. Encoded
images were printed on a Xerox Majestik color printer model
57 60. Printed
encoded images were scanned for decoding purposes using a
Hewlett Packard
Scanjet model 4C image scanner.

CLPR:
3. The method of claim 2 wherein the color difference
quantity is a single
color space direction and associated color modulation
magnitude for all image
locations in the output signal block color image; the
color space direction
and associated color modulation magnitude being computed so
that the color
values of the color modulated image regions included in the
output signal block
color image are simultaneously capable of being detected by
a digital image
capture device and are visually substantially imperceptible
to a human viewer
of the output signal block color image; the spatially
arranged pattern of
color modulated image regions in the output signal block
color image thereby
being substantially imperceptible to the human viewer.

CLPR:
4. The method of claim 2 wherein the output color image is
a gray scale **image,**
the output color value is a color included in a set of gray
scale colors that
ranges from black to gray to white, and the color
difference quantity is a
single color space direction and associated color
modulation magnitude
indicating the set of gray scale colors; the color **values**
of the color
modulated image regions included in the output signal block
color image thereby
all being included in the set of gray scale colors.

CLPR:
5. The method of claim 2 wherein the color difference quantity is a function
of an image location in the modulation pattern data structure such that the
color space direction and associated color modulation magnitude applied to the
output color **value varies by image** location in the output signal block color
image, subject to a requirement that the output color value is an average color
of all of the color **values of the color modulated image** regions in the output
signal block color image.

CLPR:
7. The method of claim 6 wherein a total **number** of message values that may be
encoded in a single output signal block color **image** is a function of a total
number of modulation **pattern** data structures and a total **number** of orthogonal
color **space** directions and **associated** color modulation magnitudes computed
using the output color value.

CLPR:
8. The method of claim 1 for operating a processor-controlled machine to
produce an output color image wherein obtaining the color difference quantity
includes assigning as the color difference quantity a predetermined color space
direction and associated color modulation magnitude in a multi-dimensional
color space that together define a fixed, predetermined additive change in the
output color value; wherein the at least two different data values spatially
arranged in the modulation pattern data structure indicate scaling data; and
wherein modulating the output color value by the color difference quantity
includes generating the color values of the spatially arranged pattern of color
modulated **image regions by varying the output color value** by the fixed,

predetermined additive change scaled by the scaling data.

CLPR:
9. The method of claim 1 for operating a processor-controlled machine to produce an output color **image** wherein the plurality of output signal block color **images** are arranged in the output color **image** in a two-dimensional **array**.

CLPR:
12. The method of claim 1 for operating a processor-controlled machine to produce an output color image further including receiving an input color image; and wherein obtaining an output color value as the unspecified reference color includes obtaining the output color **value from an image** region of the input color image.

CLPR:
18. The method of claim 16 for operating a processor-controlled machine to encode a plurality of message data items in an encoded color **image** version of an input color **image** wherein the plurality of output signal block color **images** are arranged in the encoded color **image** in a two-dimensional **array**.

CLPV:
selecting a modulation pattern data structure representing the message value of the message data item; a selected modulation pattern data structure being one of a plurality of modulation pattern data structures each uniquely representing one of the valid message values in the coding scheme; each modulation pattern data structure defining size dimensions of an output signal block color image and including at least two different data **values spatially arranged in a pattern indicating image** locations in the output signal block color image of at least two colors produced by applying a color difference

quantity to an
unspecified reference color;

CLPV:
producing an output signal block color **image using the output color value,** the
color difference quantity and the selected modulation pattern data structure;
the output signal block color image having size dimensions indicated by the
modulation pattern data structure and including a spatially arranged pattern of
color modulated **image regions having color values** produced by modulating the
output color value by the color difference quantity subject to a requirement
that the output color value be an average color of all of the color **values of
the color modulated image** regions; and

CLPV:
modulating the output color value by the color difference quantity includes
generating the color values of the spatially arranged pattern of color
modulated **image regions by varying the output color value** by the additive
change scaled by the scaling data.

CLPV:
additively combining the first and the plural additional output signal block
color images to produce a combined output signal block color **image encoding the
plural message values in the output color image**.

CLPV:
producing an output signal block color **image using the output color value** and
the selected signal block data structure indicating the predetermined color
space direction and the modulation pattern; the output signal block color
image having a spatially arranged pattern of color modulated **image regions each
having a color value** produced by modulating the output color value by the color

space direction and the associated color modulation magnitude according to the scaling data indicating the modulation pattern, subject to a requirement that the output color value be an average color of all of the color **values of the color modulated image** regions; and

CLPV:
modulating the input color value by the color difference quantity includes generating the color values of the spatially arranged pattern of color modulated **image regions by varying the input color value** by the additive change scaled by the scaling data.

CLPW:
determining an input color **value of one of the subregions of the input color image**;

CLPW:
producing an output signal block color **image using the input color value,** the color difference quantity and the selected signal block data structure; the output signal block color image having a spatially arranged pattern of color modulated **image regions each having a color value** produced by modulating the input color value by the color difference quantity according to the scaling data indicating the modulation pattern, subject to a requirement that the input color value be an average color of all of the color **values of the color modulated image** regions; and

CLPW:
the processor, further in executing the instructions, selecting a modulation pattern data structure representing the message value of the at least one message data item; a selected modulation pattern data structure being one of a plurality of modulation pattern data structures each

uniquely representing one
of the valid message values in the coding scheme; each modulation pattern data
structure defining size dimensions of an output signal block color image and
including at least two different data **values spatially arranged in a pattern**
indicating image locations of at least two colors produced by applying a color
difference quantity to an unspecified reference color in the output signal
block color image;

CLPW:
the processor, further in executing the instructions, producing an output
signal block color **image using the output color value,** the color difference
quantity and the selected modulation pattern data structure; the output signal
block color image having a spatially arranged pattern of **image regions having**
color values produced by modulating the output color value by the color
difference quantity subject to a requirement that the output color value be an
average color of all of the color **values of the color modulated image** regions;

ORPL:
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Watermarking for Multimedia. NEC Research Institute, Technical Report 95-10,
pp. 1-33.